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Investigation on Microbial Fuel Cell for Treating Wastewater

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ABSTRACT: The increasing risk of global warming by greenhouse gasses requires further development of renewable energy sources. Sharp escalation in prices and fast depletion of conventional energy sources leads to search for an alternative energy. Microbial fuel cell technology is a new type of renewable and sustainable technology for electricity generation. It recovers energy from materials that are difficult to dispose of such as sugar waste water, municipal waste water, dairy waste water and paper industry waste water. Biological hydrogen production processes are found to be more environment friendly and less energy intensive. Microbial fuel cells are electrochemical device used for converting chemical energy contained in organic matter into electricity by means of catalytic (metabolic) activity of living microorganisms. It is an alternative method to reduce cost of treatment and generate electricity. Microbial source uses dairy waste water as a substrate for the production of electricity. Microbial fuel cells have an advantage over other electricity production methods because of their high efficiency. The present work gives an emphasis on treating the dairy wastewater (secured from Milk Corporation) by using Microbial Fuel Cell (MFC) from Jalgaon that consisted of two Chambers with cathode as distilled water and anode as Dairy wastewater which result the Electric Potential value with augmentation of Pottasium Dichromate a gradual oxidizing agent ($K_2Cr_2O_7$) as an placed in Distilled Water and the Bacteria present in the dairy wastewater also gets degraded.

KEYWORDS: Microbial Fuel Cell, Dairy Wastewater, Pottasium Dichromate, Distilled cathode, anode, electric potential.

I. INTRODUCTION

It is evident that humankind is increasingly dependent on energy with the advancement of science and technology. Increased economic growth and social development are leading to a large gap between energy demands and the availability of fossil fuels. The present day energy scenario in India and around the globe is precarious, thus driving to the search of the alternative to the fossil fuels. Current methods to produce energy are not sustainable, and concerns about the climate change and global warming require developing new methods of energy production using renewable and carbon neutral sources.

In our energy based society, the value of any energy rich matter is increasing. Thus, the high organic load in waste waters is no longer seen as waste, but instead as a valuable energy resource. Finding a way to exploit this biological substrates degradation for the generation of the electricity of the driving force for the development of the microbial fuel cells (MFCs) although the concept of the electricity production from bacteria was conceived nearly a century ago by potter (Potter 1911), only recently the technology has been sufficiently improved to make it useful as a method for energy production and its capability becomes more than laboratory novelty. The reason for this recent interest in using the bacteria to generate electricity are a combination of the need for new resources of energy, discoveries about microbial physiology related to electron transport and advancement of the fuel cell technologies.

Microbial fuel cell is a bioreactor that converts chemical energy present in the organic matter into electrical energy by using microorganisms as a catalyst. This catalytic reaction takes place under anaerobic condition and the microorganisms used are termed as electricigens. The advantages of using microbial fuel cell is that they can be used at room temperature itself, easy to handle, not toxic, it can extract 90% of electrons from organic compound, self-sustaining, renewing. The disadvantage is that they cannot produce much current and scale up process is the major problem. Applications are they can be used to produce hydrogen, used in wastewater treatment, used as biosensors; desalination process can be done using microbial fuel cells. The compiled research work successfully represents the MFC as a significant technology in the dairy industry, uniting wastewater treatment and off-grid electricity production. The optimized design parameters are found out by evaluating the practicability of using different electrodes, varying detention time and increased electrode surface area.

II. LITERATURE SURVEY

1. Waste water Treatment by Sanjay et al:

Energy need has been increasing worldwide exponentially. At present global energy requirements are mostly dependent on the fossil fuels, which eventually lead to foreseeable depletion of limited fossil energy sources. In this context, regeneration of the electricity with dairy wastewater is one of the better possibilities. Now a days, countries like India in progressing towards harnessing new energy sources. Microbial fuel cells (MFCs) have been thoroughly investigated by many researchers in the past and concluded that MFCs could be applied for the treatment of liquid waste streams and also in generation of electricity. The aim of this study was to test a novel MFC design for dairy wastewater treatment and simultaneous electricity production. The hypothesis of the design was to bring MFCs closer to large scale industrialization. As such the materials and mechanics of the design were conceived with the consideration of the needs of large scale wastewater treatment plants. Higher percentage of COD and BOD removal and significant electricity generation using MFC can be achieved. Thus the combination of wastewater treatment along with the electricity production may help in saving of millions of rupees.

2. Optimization of Microbial Fuel Cell for Treating Industrial Wastewater and Simultaneous Power Generation by Aswin et al:

The dual application of microbial fuel cells (MFC) make them more prolific in research at present. In this study, microbial fuel cell was fabricated in an economical way and the experiment was carried out in two phases. In first phase of experimental run, dairy and leather effluent was used as substrate without any mediators and in second phase, dairy, leather and sewage wastewater were used as substrate with ferroin as mediator. Physiochemical characteristics such as total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand (COD), and biochemical oxygen demand (BOD) were determined before and after treating the effluent in MFC using *saccharomyces cerevisiae*. Heavy metals present in the effluent were also removed during biodegradation process. In first phase of experimental run, COD and BOD removal efficiency was found to be 80.4% and 59.3% for leather effluent, 83.4% and 64.3% for dairy effluent and in second phase, COD and BOD removal efficiency was found to be 80% and 64% for leather effluent, 85.4% and 79% for dairy effluent and 65% and 47% for domestic wastewater. The maximum power generated in first phase during the treatment of dairy and leather wastewater was found to be 385.25 μ W and 304.5 μ W and in second phase, 1.98 mW, 1.95 mW and 1.28 mW of power was generated during the treatment of dairy, leather and domestic wastewater.

3. Dairy Wastewater Treatment and Electricity Generation Using Microbial Fuel Cell by Drisya et al:

Microbial Fuel Cell (MFC) is feasible to use as an alternative to conventional wastewater treatment techniques. The compiled project work successfully represents the MFC as a significant technology in the dairy industry, uniting wastewater treatment and off-grid electricity production. The optimized design parameters are found out by evaluating the practicability of using different electrodes, varying detention time and increased electrode surface area. MFC in which stainless steel (15 \times 5 \times 0.1cm) is incorporated as electrode and Agar-NaCl salt bridge is used as proton exchange membrane is finally identified as the optimum design at 6 hours detention time with a power and electrical energy generation of 37.651 μ W and 0.0677W sec respectively. The percentage of removal efficiencies achieved in the optimized experimental setup for various parameters such as COD, Oil and Grease, BOD, EC and TDS are 93.98%, 83.82%, 90.63%, 73.06% and 72.66% correspondingly. Finally it has to be concluded that "Microbial Fuel Cell Technology" is efficient for dairy wastewater treatment and simultaneous energy recovery.

III. MATERIALS AND METHODS

1. Materials used:

- a. Anode and Cathode chambers
- b. Salt bridge
- c. Ammeter
- d. Oxidizing agent
- e. Copper wire

Salt bridge must consist of agar agar gel and NaCl in a proper proportion.



Fig 1: Salt Bridge Construction for treating wastewater and Multimeter for measuring current.

2. Procedure Set up:

- a. The mfc consists of two chambers anode and cathode.
- b. A salt bridge is constructed in between the two chambers.
- c. In anodic chamber distilled water is added and in cathodic chamber the dairy waste water is added.
- d. In both the chambers the copper wires are placed in the electrolyte and both wires are connected to ammeter.
- e. Ammeter shows the rate of generation of electricity and the rate of treatment of waste water.



Fig 2: Design set up of Salt Bridge



3. Design of Setup:

Many different configurations are possible for MFCs. A widely used and inexpensive design is a two chamber MFC built in a traditional “H” shape, consisting usually of two bottles connected by a tube containing a separator which is usually a cation exchange membrane (CEM) such as Nafion or Ultrex , or a plain salt bridge. The key to this design is to choose a membrane that allows protons to pass between the chambers (the CEM is also called a proton exchange membrane, PEM), but optimally not the substrate or electron acceptor in the cathode chamber (typically oxygen). In the H-configuration, the membrane is clamped in the middle of the tubes connecting the bottle. However, the tube itself is not needed. As long as the two chambers are kept separated, they can be pressed up onto either side of the membrane and clamped together to form a large surface. An inexpensive way to join the bottles is to use a glass tube that is heated and bent into a U-shape, filled with agar and salt (to serve the same function as a cation exchange membrane), and inserted through the lid of each bottle. The salt bridge MFC, however, produces little power due the high internal resistance observed. H-shape systems are acceptable for basic parameter research, such as examining power production using new materials, or types of microbial communities that arise during the degradation of specific compounds, but they typically produce low power densities.

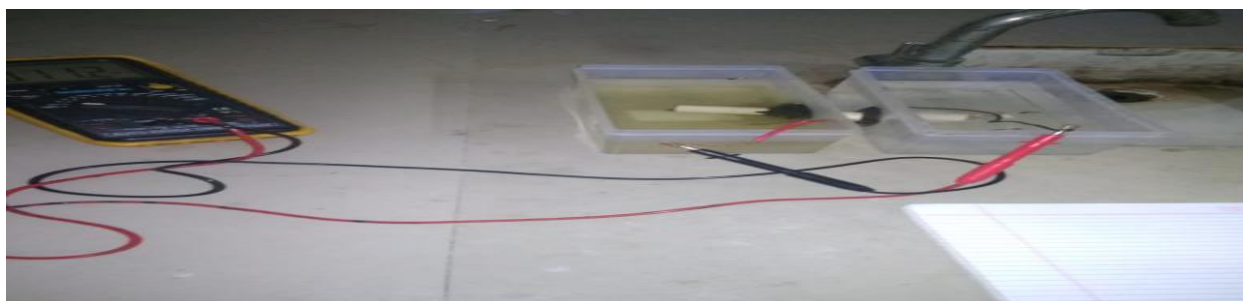


Fig 4: Design set up of MFC

4. Characteristics Tests performed on the Wastewater:

The 4 Characteristics tests were performed on the wastewater that are as follows:

- a. Physical Characteristics: Turbidity
- b. Biological Characteristics: Biochemical Oxygen Demand (BOD)
- c. Chemical Characteristics: Chemical Oxygen Demand (COD)
- d. Sludge Value Index (SVI)

IV. RESULTS AND DISCUSSION

1. Dairy Wastewater Treatment by MFC:

Table 1: Dairy Wastewater Treatment:

NAME OF TEST	DAIRY WASTE WATER BEFORE TREATMENT	DAIRY WASTE WATER AFTER TREATMENT
BOD	300mg/lit	189 mg/lit
COD	350mg/lit	197 mg/lit
TDS	16	9
pH	8	7
SVI	3	1

From the above table it can be seen that efficiency of the BOD removal from the wastewater is 37%, efficiency of COD removal is 43.71%, BOD/ COD ratio which is final is 0.96 which means effective degradation of micorbes. Others parameters too decrease pH to becomes neutral.

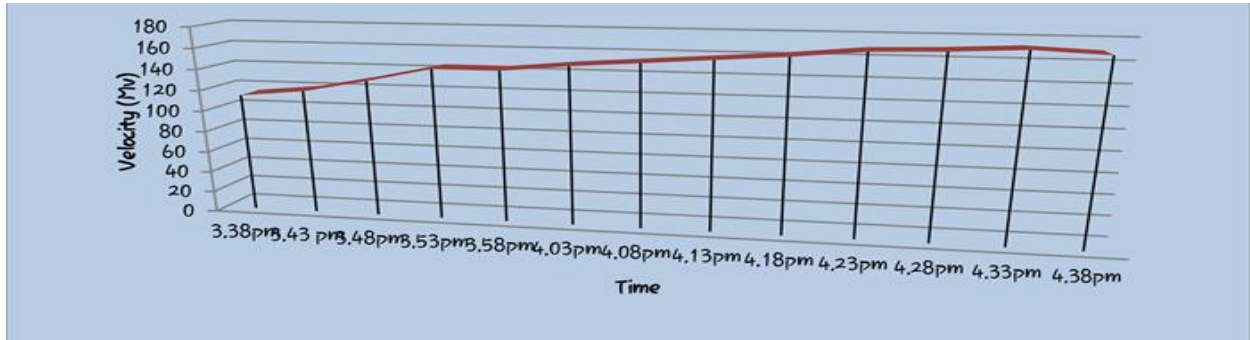


Fig 5:Graphical presentation of Dairy Waste Water with respect to amount of electricity generation

From the above graphical representation it can be seen that the electricity generation via the fuel cell substantially increases with the time, the reason behind this is that the cation anion exchange via the fuel cell.

2. Hostel Wastewater Treatment:

Table 2: Hostel Watewater Treatment

NAME OF TEST	HOSTEL WASTE WATER BEFORE TREATMENT	HOSTEL WASTE WATER AFTER TREATMENT
BOD	320mg/lit	192 mg/lit
COD	361mg/lit	198 mg/lit
TDS	15	7
pH	8	7
SVI	3.5	1.5

From the above table it can be seen that efficiency of the BOD removal from the wastewater is 40% which is better than the dairy wastewater, efficiency of COD removal is 45.15% also better than the dairy wastewater, BOD/ COD ratio which is final is 0.97 which means effective degradation of micorbes. Others parameters too decrease pH to becomes neutral.

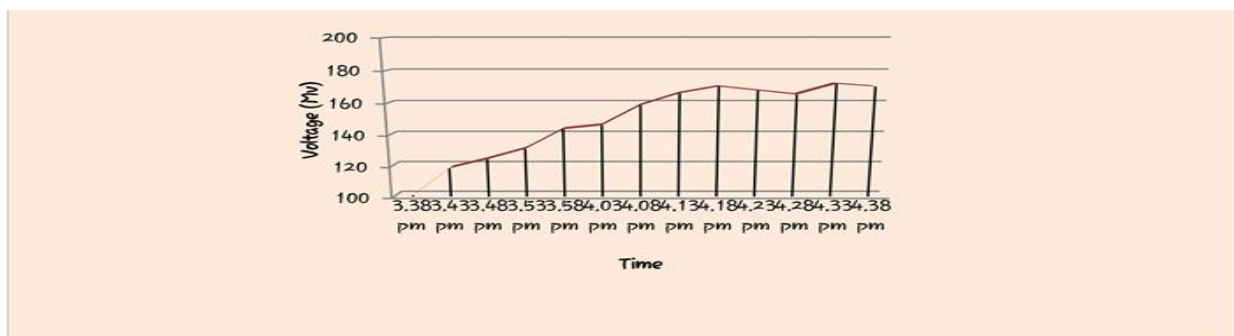


Fig 6: Graphical presentation of Hostel Waste Water with respect to amount of electricity generation

From the above graphical representation it can be seen that the electricity generation via the fuel cell substantially increases with the time, the reason behind this is that the cation anion exchange via the fuel cell, even better than the dairy wastewater.

V. CONCLUSION

- The results obtained from the following experimental data shows us that more electricity is.
- It is acquired from mediator and yeast rather than only yeast or with only mediator for dairy waste Water.
- The value of voltage category change according to the type of microorganisms used.
- The mediator enhances the transfer of electrons and thus increasing the acquired voltage.
- The more the dairy water or urine or sewage waste water chambers are kept for degradation, better the results are obtained up to a certain limit.
- In sewage waste water microorganisms play a vital role in producing large number of electrons and if a mediator is introduced it enhances the increased transfer of electrons which help to get better results.
- Results for sewage treatment may vary from mediator to mediator and also from electrogenic microorganisms to some other kinds.
- This shows that the MFC is relatively efficient waste water treatment system. A moderately efficient, recyclable. Waste water treatment system is the first to an alternatively energy resources that is copied with cleansing of the environment.

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